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The Gift of Thos. Hollis, of Lincoln's Inn
London
EXPERIMENTS and OBSERVATIONS

ON

AMERICAN POTASHES.

WITH

An easy Method of determining their
respective Qualities.

By ^{William} W. LEWIS, M. B. F. R. S. 2 — 1781.

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OBSERVATIONS ON AMERICAN POTASHES.

THE eight sorts of Potashes sent to me by the society are all of a dark colour, some almost black; some have a reddish cast, and others appear on breaking of a cherry or rose red, which soon changes to a dusky hue on being exposed to the air.

They are all compact, hard, and slow of solution: though they soon liquefy on the surface, they do not readily dissolve, even by boiling in water, unless reduced to powder.—Some other sorts of Potashes from *America*, which were sent to me for examination about a twelvemonth ago by persons concerned in the trade, are much whiter, more friable, and easier of solution.

Some of these Potashes have a considerable degree of causticity, though none of them so much as the other sorts above mentioned. The workmen I have consulted complain, that the causticity of the *American* Potashes in general is so great, that the skin and clothes are often corroded by the fragments, which fly about in breaking the hard masses.

B

—Lyes

Lyes made from these Potashes with cold water are sufficiently pale, the colouring matter remaining undissolved: lyes made by boiling in water are deep coloured at first, but soon deposite a dark sediment, and become pale as the others: The lyes of some of them, though well loaded with the salts, are colourless as water.

Several of these lyes, though of little colour themselves, give a black stain to silver, tin, and copper: the filtered liquor by being boiled in a tin pot became also blackish: on standing, the black matter precipitated, and the clear lye no longer discoloured the metal.

On adding an acid to the lyes, some contract a slight untransparence, and yield a fetid smell like that of the washings of a gun-barrel: others retain their transparency, and give little or nothing of this smell. It is probable, that both the smell and staining quality depend upon one cause, an impregnation of sulphureous matter.

To determine the quantity of salts in these Potashes, four ounces of each of the sorts were boiled in water, the solutions filtered, and the residue on the filters washed with fresh portions of boiling water, till the water passed through tasteless. The solutions were boiled down separately in an iron pot, and the salts continually stirred and scraped from the pot as they became dry. Most of the salts, after being kept for some time in a moderate heat, below red-hot, appeared pretty white, some with a yellowish, some with a greenish, and some with a dusky greyish cast; some of them were difficultly dried, and after they had become dry, seemed disposed to melt. The salt which had
this

this property in the greatest degree, was that of the Potash which seemed the most caustic, marked A A. The quantity of salt from most of them was about three ounces, and $\frac{1}{3}$ of an ounce. The lowest yield, *viz.* from E, was $3\frac{1}{2}$ ounces; and the highest, *viz.* from B $3\frac{3}{5}$, from four ounces of the Potashes.

These Potashes appearing to be all sufficiently rich in salt, I endeavoured to discover by crystallization whether they contained any other kind of salt than their proper alkali. Four ounces of each of them being elixated as before with boiling water, the filtered solutions were evaporated to somewhat more than half a pint each, and set to cool in stone basons. A considerable portion of salt fell to the bottom in all, though pure alkaline salt would not have separated from such a quantity of water. The salt from G was in largest quantity; and was therefore made choice of for further crystallization.

This salt discovering to the taste that it retained much of the alkali, it was cautiously washed with a little cold water, and this put to the rest of the lixivium. More cold water being added to the salt, great part of it dissolved by stirring and shaking, some very difficultly; a part remained undissolved, which felt gritty like sand, and tasted bitterish like vitriolated tartar. The solution being filtered and set to evaporate in a stone basin with a gentle heat, a pellicle formed on the surface, and some salt fell to the bottom in fine powder; in cooling more salt fell in small grains like dust. The liquor, which tasted alkaline, being poured off, the salts were again dissolved in water: in evaporation the

same separation happened of a salt in fine grains, which seemed to be vitriolated tartar; and on cooling large crystals formed, not unlike sea-salt, but extremely tender, and still somewhat alkaline to the taste; a little quantity of the moist grains held over the fire in a silver spoon, liquefied before the spoon could be perceived to be warm, and dried into a white powder, which tasted like a mixture of sea-salt with a little alkali and vitriolated tartar: the powder being put on the point of a knife, great part of it melted just as the knife became red-hot; some grains remained unmelted.

It appears from the above experiment, that the salts of these Potashes are not purely alkaline, but contain a mixture, some of them a very large one, of salts of another kind; but the perfect separation of these foreign salts by crystallization, either from the alkali or from one another, especially when the process is performed with small quantities of the matter, was found so difficult and tedious, that the enquiry was dropt, and another way of examination tried.

Having extracted the whole of the saline matter from the several Potashes, it was judged that the quantity of true alkali in the salts might be discovered by their power of saturating acids, compared with that of an alkali of known purity; and this method succeeded so well, that it is hereafter proposed for the assaying of Potashes, and the manner of procedure described at large. It was thus found that of the salt extracted from the Potash G, more than one third part is not alkaline.

According to these experiments, the quantities of salt contained in a pound or sixteen ounces

ounces of the several Potashes, and the quantities of alkaline and foreign salts of which the several salts consist, are as follows :

	Ounces of salt.	Ounces of al- kali in the salt.	Ounces of salt not alkaline.
A	— 13 $\frac{7}{10}$ —	— 11 $\frac{7}{10}$ —	— 2
AA	— 13 $\frac{4}{10}$ —	— 12 $\frac{5}{10}$ —	— $\frac{9}{10}$
B	— 14 $\frac{4}{10}$ —	— 9 $\frac{8}{10}$ —	— 4 $\frac{6}{10}$
C	— 13 $\frac{6}{10}$ —	— 11 $\frac{3}{10}$ —	— 2 $\frac{3}{10}$
D	— 13 $\frac{7}{10}$ —	— 11 $\frac{4}{10}$ —	— 2 $\frac{3}{10}$
E	— 12 $\frac{8}{10}$ —	— 10 $\frac{4}{10}$ —	— 2 $\frac{4}{10}$
F	— 13 $\frac{6}{10}$ —	— 10 $\frac{9}{10}$ —	— 2 $\frac{7}{10}$
G	— 13 $\frac{7}{10}$ —	— 8 $\frac{3}{10}$ —	— 5 $\frac{4}{10}$

Observations on the American process of making Potashes.

TO judge how far the hardness and slowness of solution, the causticity, staining quality, and foreign salts, of the *American* Potashes, might depend on the circumstances of their preparation, or designed abuses, I procured from different persons conversant in this manufacture, the best information I could of the method of making Potashes in *America*, and repeated the process myself.

There is very little wood burnt on purpose for this work, greatest part of the Potash being made from the ashes of wood burnt in common chimneys for domestic uses. The woods chiefly employed are the hickory, oak, beech, birch, elm, walnut, chesnut, and maple: different sorts are burnt together, old and young, green and dry; and if one sort should sometimes be burnt by itself, the ashes are not kept separate, but put to the same heap with others. It is said by some that a ton of Potash is obtained from

from 400 bushels of ashes ; by others from 450 bushels ; by others from 560 of the best ashes, and double that quantity of the worst, most commonly from 700 bushels ; some think that the beech yields most salt, others that the oak yields most, and the walnut least ; but that the difference is not great.

The ashes are collected from the country people in winter, and laid in heaps under sheds, or in other convenient covered places, till May or June ; not that they are supposed to be any ways improved by keeping, but because the Potash manufacture is carried on during the summer only, the frost rendering the elixation impracticable in winter ; at the time of using, they are moistened with water, or weak lye, to lay the dust.

The lye is made from the ashes in backs or vats, the dimensions of which are said to be 8 feet by 10, and 18 inches deep ; and three of them which are set at once, to hold 500 bushels. As three vessels of such dimensions are scarcely equal in capacity to 300 bushels, the ashes must either be rammed down hard, or heaped above the sides, or both. Some water is poured on the top, and as fast as it soaks in, more water is put on. According to some, the water is suffered to stand for a week on the ashes ; according to others, it is not stopt at all, but runs out as soon as it has penetrated to the bottom in a small stream of a dark-brown, or chocolate colour. They continue putting more water on the ashes, till, by the colour and weight of the lye, it is judged that all the salt is extracted. The first lyes, and as is thought the second also, are conveyed into a cistern to be boiled down,
the

the others are reserved to be poured on fresh ashes.

The lye is boiled down in iron pots, some of which hold 60 gallons, though many are less, and some are said to be so large as to hold 80 gallons. Two pots are hung together in brick-work in such a manner, that the fire acts upon the sides as well as on the bottom. The bottoms are subject to crack or split. It is said that some persons in *America*, having contrived to cast them with the bottoms downwards, so that the bottom is formed of the heaviest and most solid part of the metal, this inconvenience is in good measure prevented.

As the lye evaporates, more is laded in, a gallon or two at a time, till the pots are judged to have a sufficient charge of salt. The salt, in becoming dry, grows so hard, and sticks so firmly to the sides and bottom of the pot, as not to be got off without much labour; but accident has lately discovered to the manufacturers a method of avoiding this most troublesome and tedious part of the process. Instead of waiting till the pots are grown somewhat cool, and getting out the salt with mallets and chisels, as formerly practised, they increase the fire till the pot becomes red-hot and the salt melts; in which state it is conveniently taken out with iron ladles, and cast either on a dry floor, paved on purpose, or in old iron pans. Before fusion, the salt is brown; in fusion it turns of various colours, blackish, reddish, &c. Some suspect that a little common salt is added to make it melt more easily.

I performed this process with ten bushels of ashes procured from some farm-houses, where
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oak, birch, ash, elm, and hazel are burnt. The ashes were put into two tubs, which had false bottoms covered with fern and hair-cloth, supported by pieces of bricks above the true bottom. Being rammed pretty close to the sides to keep the water from slipping down between, and a cavity being formed in the middle, some water was poured gently on the ashes in one of the tubs, and more water added as fast as it soaked in. In about two hours the liquor had penetrated to the bottom, and began to run out of a deep brown colour: we continued putting on more water, and examined the strength of every pail-full of the lye by an hydrometer, which will be described hereafter. The first pail appeared to hold about three quarters of an ounce of salt on the pound avoirdupois; the second pail near $1\frac{1}{4}$ oz. the third above $1\frac{1}{2}$, the fourth and fifth $1\frac{3}{4}$, after which the strength gradually diminished. When the lye run weak, it was stopt, and suffered to stand some days on the ashes, by which its strength was increased from $\frac{1}{4}$ to above $\frac{1}{2}$ an ounce on the pound. It appears therefore to be of advantage to let the water stand some time on the ashes. The above lyes being passed successively through the second tub of ashes, the first pail appeared to hold $2\frac{1}{4}$ ounces of salt on the pound; the second nearly the same; the third somewhat less than two ounces. It should seem therefore unfrugal to carry any of the first lyes to the boiler, as their strength is so greatly increased by passing through fresh ashes.

All the above lyes that seemed of moderate strength were mixed together, boiled down in a large copper to about one third, and then
laded

laded by degrees into iron pots, placed in proper furnaces, till the quantity of salt in the pots was as great as could conveniently be dried in them. One pot charged with seven or eight pounds of the dry salt, was hung in the furnace by its rim: the salt melted, but not before the rim of the pot became red-hot; a kind of crusty matter continuing unmelted on the surface, probably from the contact of the air: the fluid salt laded out into another iron vessel, concreted into a hard, compact, dark-coloured mass, which easily came out of the vessel on turning it upside down, and greatly resembled some of the *American* Potashes: the mass being broken, several of the pieces turned in a short time whitish on the surface. Some of this Potash was put into the same pot, with an addition of $\frac{1}{2}$ of common salt: it melted much easier than without the common salt, this last coming first into fusion, and dissolving the other; a crust still formed on the top: when cold, the surface was of a brownish green colour, but in a day or two turned white. The same quantity of the Potash, in a large iron crucible placed among the fuel in the same furnace, flowed thinner than in the foregoing circumstance, but still contracted a crust on the top, though less thick; and on trying some of the *American* Potashes, they gave the same appearance. Ten pounds of our Potash were kept in fusion with a strong fire for two hours, and the crust continually broken and pushed down; part continued to rise again, and was at length scummed off; part seemed to have settled to the bottom, for on lading out the fluid salt, an unmelted matter remained behind; so that though the

crust may proceed in part from a portion of the salt cooled by the contact of the air, it seems also that a part of the earthy substance of the Potash is thus thrown off. By this continuance of fusion the Potash did not become at all whiter: it inclined in some places to purple, broke more easily than before, and appeared of a large broad granulated texture.

This Potash agrees with the *American* in slowness of solution, apparently from the compact texture occasioned by the fusion.

From the same cause these melted salts are very difficultly, if at all, convertible into a good pearl-ash by the common process of calcination. Several pieces both of the *American* and my own, about the size of walnuts, were placed under a muffle, open at both ends, so contrived that the fire lay all on its upper part. The Potashes were kept for upwards of six hours of a slight red heat, so as just not fully to melt, and occasionally turned and moved to more or less hot parts of the muffle, and the flame of wood suffered at times to pass over their surface; several of the pieces became smooth and greenish on the outside; but on breaking, they did not appear altered in any respect. Some pieces of the crust that had been scummed off in the fusion of the Potash, being less disposed to melt than the rest, contracted no smoothness or glossiness; they became white, but not to any considerable thickness.

These salts receive from the fusion one valuable quality. Their oily matter being burnt to an indissoluble coal, they give a pale or colourless lye; while those which have not suffered fusion

sion or a red heat, give always a brown or deep-coloured lye.

This Potash agrees also with the *American* in some other properties, which might less be expected. Solutions of it stain silver, and yield a fetid smell on the addition of an acid. The quantity of pure saline matter obtained from it, is somewhat less than thirteen ounces on the pound; and of these thirteen ounces, two ounces or more appear from the trial with acids to be a foreign salt; so that it is nearly of the same degree of impurity with the *American* Potashes, C and D.

The impurity of this Potash is easily accounted for from the common salt, which the ashes of kitchen-fires cannot fail to partake of. But as the quantity of wood burnt in the *American* colonies during the winter, is doubtless far greater in proportion to the number of people, and consequently in proportion to the quantity of provisions dressed, than in our farm-houses; the *American* Potashes cannot be supposed to be affected by this cause in an equal degree with ours. It may be presumed that seven sorts out of the eight before examined have a designed addition of the sea-salt; more especially as the remaining one A A, was found to contain not half so much as any of the others. In two of them, B and G, the quality of the foreign salt is such, that there are grounds to believe that sea-water has been used instead of common water for making the lye from the ashes. — As almost all the common sorts of sea-salt participate of the salt of the bittern of the sea-water, the combination of the vitriolic acid of that salt with the inflammable matter, during fusion, is prob-

bably the origin of the sulphureous taint, both in the *American* Potashes and mine.

There is one property in several of the *American* Potashes, causticity, which I do not conceive to be communicable by any circumstance, either in the process itself, or that can happen to the ashes of common fires, without a designed addition. The above Potash from farmhouse ashes, and a salt which I prepared on purpose from bakers ashes, had no causticity, either when the lye was simply evaporated to a dry brown salt; or when this salt was melted into a black mass; or when it was calcined to perfect whiteness; or when the salt was extracted by water from the black mass, and again boiled down to dryness; the salts in all these states seeming to be as mild as common salt of tartar. It may therefore be presumed, that the causticity of the *American* Potashes does not proceed from the manner of their preparation, but from an addition of quicklime.

It is affirmed by Dr. *Brandt*, in the *Swedish* transactions, that vegetable ashes themselves may be converted by fire into a true quicklime, soluble in water like the common quicklimes, impregnating it with the same taste, and giving the same causticity to alkaline salts. I therefore took some bakers ashes, from which all the salt had been extracted that could easily be got out with warm water, and kept them red-hot in a crucible for an hour: being then put into water, they did not impart to it any taste, or any of the common properties of lime-water. Another quantity of the ashes was kept in a stronger red heat for two hours; they communicated to so much water as just covered them,
a taste

a taste like that of very weak lime-water, and the liquor became milky, as lime-water does, on dropping in an alkaline lye. Another portion of the ashes was kept for two hours in such a heat, that the part next the bottom of the crucible melted into a kind of semi-transparent glass: the upper part baked into a dark-coloured friable mass, gritty like sand, which gave to water a taste like that of pretty strong lime-water. This liquor contracted a skin or thin crust on the surface, and grew very milky with alkaline lye, but did not suffer any change of transparency, as the common lime-waters do, from vitriolic acid.

It appears therefore, that though vegetable ashes may be brought by fire to have some of the properties of quicklime, and though in this state they should be capable of giving some causticity to alkaline salts, yet they do not become perfectly the same with the common quicklimes; and the degree of fire necessary for producing this change is such, that the salts of common chimney-ashes cannot be supposed to receive any causticity from this cause.

General observations relative to the assaying of Potashes.

THE best Potashes contain always some quantity of indissolvable earthy matter; some of those which have been long used in certain businesses, as the *Russian*, a very large one. What proportion of vegetable earth may be allowable in good Potash, and what proportion shall be deemed to render the commodity unfit for market, I cannot pretend to judge. Perhaps
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it may be advisable to allow a very considerable latitude, and to affix proper marks on the tubs, that their value may be known.

As all Potashes, those at least which are made from the ashes of kitchen-fires, must be expected to contain marine salt, a latitude must be allowed also in this respect. A small proportion of sea-salt can scarce be suspected of being very injurious in the businesses where Potashes are chiefly employed: a large one may be of real detriment, independently of the consumer being defrauded by it of the due quantity of alkali. Dr. *Home* relates, that in bleaching of linen, sea-salt mixed with the Potash injures the cloth, by opening, thinning, and weakening it; and that some skilful bleachers have rejected a Potash, which according to his account does not contain so much sea-salt as two of the *American* sorts above examined.

The sulphureous taint or staining quality, which seems, as already observed, to proceed from the vitriolic salt, of which almost all the common sorts of sea-salt participate, will probably be of more general injury than the pure marine salt; and therefore Potashes, which have this impregnation in a great degree, may deserve to be condemned, or at least ought to be properly distinguished. An experiment already mentioned gives room to hope, that low degrees of this taint may be remediable, or that the staining matter may be separable by certain additions.

Different lumps of Potash taken out of one tub, and the top and bottom parts of the quantity melted in one pot, differ both in appearance and quality. This difference was sufficiently sensible, even in the small parcels of the
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several sorts of Potashes sent to me. The same precaution therefore ought to be used here as in the assaying of certain ores: pieces should be broke off from the most dissimilar lumps in different parts of the tub, to the quantity of half a pound or more; all the pieces reduced to powder together in a dry and warm mortar; and the quantity necessary for the assay taken from this powder; or if this is too troublesome, the assay quantity should at least be taken from several pieces, never from a single one.

Habit will enable an attentive observer to form some judgment of certain qualities of Potashes, from the appearance of the mass, or from the operations, which are only preparatory to the direct assay. In making a solution of the Potash in water, he can judge in some measure by the eye, whether it contains very little or very much indissoluble earthy matter. If any sand has been mixed with the Potash, the sand will settle first, and may be easily known by its grittiness; the pale or high colour of the lye will shew whether the oily matter has been sufficiently burnt out or not; and a piece of bright tin dipt for a little while in the liquor, will discover any injurious degree of sulphureous taint.

Of discovering marine or other foreign salts mixed with Potashes.

IT is observed in the assaying of ores, that the alkaline flux and sea-salt, put into the crucible, do not unite in fusion, the sea-salt floating upon the surface of the other, and forming, when cold, a distinct cake. It was hoped that
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on this principle, sea-salt mixed with Potashes, might be separated and obtained distinct by simple fusion. In a variety of experiments made with the *American* and my own Potashes, and with known mixtures of pure alcali and common salt, with and without inflammable additions, the separation was sometimes very manifest, sometimes not perceptible, and no where so perfect, as to fully answer the intended purpose.

Another property of the marine and other neutral salts, of being thrown down from their solutions by spirit of wine, while the proper alkaline salt of Potashes continues dissolved, promised better success. A saturated solution of pure alkaline salt being shaken in a vial with about an equal quantity of rectified spirit of wine; the two liquors separated on standing for a moment; the spirit rising to the top, and the alkaline solution collecting itself at the bottom, both of them transparent as at first. When some sea-salt was dissolved along with the alcali, the spirit produced an opaque milkiness in the lye; and on standing for a few minutes, a saline matter separated and fell to the bottom; sometimes in a powdery, and sometimes in a fair crystallized form. Solutions of the *American* and my own Potashes being examined by this method, a saline matter was thrown down from all of them, from A A in small quantity, from B and G in a very large one. It was hoped that these salts were no other than the pure marine or other foreign salts contained in the Potashes, which might thus be at once separated and collected by themselves: but it was found on many trials, that they always retained a very consider-

able portion of alkali. When only sea-salt and salt of tartar were dissolved together, the salt precipitated from the solution by spirit of wine was not pure sea-salt; it had little of the true muriatic taste, the alkali seeming to prevail; it did not decrepitate, or but very slightly, in a red-hot iron ladle; and its quantity appeared much greater than that of the sea-salt employed. Saturated solutions even of alkaline salt and sea-salt, mixed together in equal quantities without any other addition, grew milky and thick, and threw off a large portion of crystalline salt similar to the foregoing; of the same kind also was great part of the salt obtained by crystallization from the *American Potashes*. It is not necessary in this place to inquire into the cause of the singular separations which happened in these experiments: Thus much only it imports the assayer to know, that when Potash contains marine or other foreign salts, a strong lye of the Potash will grow milky, and deposite a precipitate on adding about an equal measure of rectified spirit of wine; and that according as the marine salt is in greater or less quantity, the precipitate also will be more or less copious.

If a lye made from Potashes be fully saturated with pure aqua fortis, minute portions of sea-salt may be discovered in it by the common method with solution of silver, or, what will answer as well, solution of lead. But as all common spring waters contain marine salt enough to turn milky with these solutions, all Potashes must be expected to do the same. Indeed, if the solution of lead was made always exactly of the same strength, and the lye made from the same quantity of Potash with rain or snow water, as the existence of marine salt in the lye

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would be known by its turning the solution of lead milky, and precipitating the metal; so the quantity also of the marine salt might be estimated from the quantity of the lye necessary to precipitate all the lead from a certain determinate weight of the lead solution. But a process of this kind would be greatly too troublesome and tedious to be proposed for a trial of Potashes.

The quantity of marine or other foreign salts in potashes is investigable in another way. The strength of lyes, or the degree of their impregnation with saline matter, may be judged by a method already familiar to the workmen, and which I have therefore taken no small pains to improve, both in point of accuracy and convenience. The quantity of pure alkaline salt we shall likewise find means to determine with exactness. If then the one trial shews, that any Potash contains, for instance, fourteen ounces of saline matter in the pound, and the other that it contains but twelve ounces of pure alkali in the pound; we may conclude, I imagine satisfactorily enough, that the quantity of foreign salt in the pound amounts to two ounces.

Hydrostatic assay of the strength of lyes, and of the quantity of saline matter contained in Potashes.

THE quantity of salt in saline solutions is estimated, from the excess of the weight of a certain measure of the liquor, above that of an equal measure of common water. On this principle, the soapboilers and others judge of the strength of lyes by weighing a quantity of the lye in a narrow necked bottle. A set of weights
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is made on purpose for this use, called carats or cadukes. The bottle being tared and filled with water, the weight of the water is divided into two equal parts, and a weight made equal to one of these is marked 64; by continuing the division are obtained the weights, 32, 16, 8, 4, 2, 1 carats; so that a carat is the 128th part of the weight of the water. Another weight is made which counterpoises the bottle when filled with water; so many carats as the bottle filled with lye weighs more than this water-poise, so many carats strong the lye is said to be. A fully saturated solution of pure alcaline salt is about sixty-four carats, or half as heavy again as water; but the strongest lyes commonly made for soapboiling or other purposes, do not amount to half that weight; and hence the sixteen carat weight, with the four subdivisions of it, are sufficient for common use.

It would be much more convenient and expeditious to weigh the bottle in the lye. The trouble of emptying and filling the narrow mouthed vessel is thus avoided: The bottle is easier cleaned on the outside than within; it is not needful to wait, as in the other way, till the lye settles fine; and as there is much less weight upon the beam, the balance will turn with much greater nicety.

Either the soapboilers bottle, or a common vial, about the size called four ounce vials, may be easily fitted up for being weighed in lyes. The vial is to be loaded with shot, so that when corked it may sink in strong lye. Thrust a large pin through the cork, from below upwards, that the head may prevent it from being drawn out; and bend the pin, at the top, that it may hang

on a hook at the bottom of one of the scales of a balance. To keep the cork from being penetrated by the lye, it may be dipt in melted white wax, and hung by the fire, that as much as possible of the wax may soak in; after which, the wax that may remain on the outside is to be wiped off clean with a cloth.

Though a common vial may thus easily be fitted up at any time by the operator himself; yet glass bubbles, where they can be procured, such as are commonly used in hydrostatical experiments, are preferable; as being of greater accuracy, and equal convenience. To the knob or loop of the bubble tie a piece of fine brass wire, about two inches long, with a loop at the top to hang on the hook of the scale.

About the middle of the pin or wire, by which the instruments are hung to the scale, a mark is to be made, by flattening them a little with a blow of the bec of a hammer. For holding the liquor to weigh them in, there should be a glass vessel of such size, that they may be wholly immersed to the mark, without touching the bottom, and that they may hang clear of the sides. Weigh them first in water; and make a weight, which, being put in the opposite scale, shall counterpoise them as they hang in the water, taking care that the surface of the water come just to the mark on the wire or pin; then wipe them dry; and having hooked them on the scale again, weigh them as they hang in the air. So much as they weigh more than the above waterpoise, will be the weight of a quantity of water equal to them in bulk; and by dividing this weight, a set of carat weights may be made in the same manner as for the soapboiler's bottle. So

many

many of these carats as are necessary in the scale over the vial or bubble to make them sink to the mark in any given lye, the waterpoise being in the opposite scale, so many carats strong the lye is. I made a set of carat weights for the soap-boilers narrow-necked square bottle, for a common four ounce vial, and for a glass bubble; and on examining the same lye, with each of the instruments, found that all the three gave exactly the same strength.

The common hydrometer is much more convenient in use than any of the above instruments, but it is also much less accurate. A stem of any moderate length does not admit of a sufficient number of distinct divisions, so that in such an extent of strength as from water up to strong lye, it can distinguish only very gross differences. I have therefore endeavoured to improve this instrument, and bring it in some measure to the accuracy of the bubble, by using a scale and weights instead of the divided stem.

This hydrometer consists of a hollow copper ball, at least two inches in diameter, with a stiff piece of copper or brass wire passed through it, not above $\frac{1}{2}$ th of an inch thick; the wire is foldered tight to the ball, and projects about two inches above, and three below it. On the top of the stem or upper portion of the wire, is fixed a thin concave brass plate for a scale; and on the bottom of the wire is screwed a leaden or rather brass bullet, of such weight as to sink the instrument in water to a mark made about the middle of the stem; being then put into a lye of the strength of eight carats, the weight necessary in the scale on the top to sink it in this lye was marked 8, from which all the

the other carat weights were easily made. The instrument being afterwards examined in different lyes, was found to correspond exactly with those above described. The distance of the weight at bottom from the ball, keeps the instrument from tipping with the weights on the top; and the slenderness of the stem renders a minute variation in the gravity of the liquor very sensible: less than a quarter of a carat sinks the whole length of the stem, or two inches, so that the instrument will rise or sink above a quarter of an inch of the stem by a difference of less than a thirty-second part of a carat. The tin case, which serves both for keeping it in, and for holding the liquor to be tried with it, is a little shallower than the height of the hydrometer itself, that the scale may never sink so low as to be wetted. The quantity of liquor used every time should be such, as to rise nearly to the top of the case when the hydrometer is immersed. It will be convenient to have a mark in the side, at the height where this quantity of liquor rises to before the instrument is put in.

As the carat weights shew only the comparative strength of lyes, not their actual strength or the quantity of salt contained in them; I contrived a set of weights on another principle. Some pure salt of tartar is melted in an iron ladle, that all remains of watery moisture may be expelled from it. An ounce of the salt, weighed out while warm, is dissolved in fifteen ounces of water. The weight which sinks the hydrometer in this solution is marked 1 oz. By doubling this, is made the weight 2 oz. and by dividing it 8, 4, 2, 1, drams. So that the weight or weights necessary to sink the instrument in any given lye, express
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at once the ounces and drams of salt which a pound of the lye contains. If the water, in dissolving the salt, received no augmentation of its bulk, or if equal additions of salt gave equal augmentations; weights made in the above manner, would shew always the exact quantity of salt in the liquor, from the weakest up to the strongest lye. On trial with different lyes of known strengths, so far as the above set of weights reaches, which is as far as the highest carat weights used in business, it appeared, that they come sufficiently near the truth for any common purposes, though not to minute exactness; and that the further they are carried beyond the above limits, the strength expressed by them varies more from the real strength of the lye; as if the fourth ounce increased the hydrometric weight less than the third; and the fifth ounce less than the fourth.

To ascertain this point, a great number of experiments were made, many of which served only to shew the irregularities to which trials of this kind are subject, and the difficulty of attaining to physical precision; some of them however appeared decisive. A glass bubble hung by a horse-hair in a quantity of water equal to four times its bulk, was counterpoised by a weight in the opposite scale, and 120 grains of salt of tartar made by myself were dissolved in the liquor; the proportion of salt to the water was nearly as 1 to 48. If the water received no augmentation of bulk, the bubble would have lost in this solution $\frac{1}{4}$ part of 120, viz. 30 grains; but it lost no more than $24\frac{1}{2}$. If the augmentation of bulk proceeded uniformly according

to the quantity of salt added, it would have lost $24\frac{1}{4}$ grains more on every successive addition of the same quantity: but the loss continually diminished, so far as the experiment was carried, the numbers corresponding to seven successive quantities being $24\frac{1}{4}$, 24, $23\frac{1}{2}$, 22, 22, 21, 20. Eight times 120 grains were then added at once. The loss of the bubble corresponding to this quantity was 144 grains, or 18 at a medium for every 120. So that the larger the quantity of salt, the less was the ratio of the increase of the weight, and the greater was the ratio of the increase of the volume.

It appears therefore, that for making an hydrostatic assay of Potash, the quantity of salt in the liquor ought to be small. When only one part of alcali was dissolved in 63 parts of water, little or no augmentation could be perceived; the actual loss of the bubble, in four times its bulk of the liquor, being almost exactly one fourth part of the whole quantity of salt dissolved. Mr. *Eller*, in a paper on the solution of salts in the *Berlin* memoirs, observes also, that water dissolves $\frac{1}{4}$ its weight of alkaline salt without having its bulk increased. This proportion therefore may be fixed upon as a standard, and within this latitude we need not be afraid of any sensible error.

To make the assay weights, half an ounce of pure salt of tartar, perfectly dried, as already mentioned, by melting in an iron ladle, is dissolved in 63 half ounces of water; and the weight which sinks the adjusted vial, or the bubble, or the hydrometer in this lye, is marked 16, denoting, that 16 ounces in the pound, or the whole quantity

quantity of the matter added to the water, is pure salt. From this weight are made, by division, the weights 8, 4, 2, 1, $\frac{1}{2}$, $\frac{1}{4}$: so that if a lye be made from any Potash with the above proportion of water, the weights necessary to sink the instruments in the lye will express the ounces of pure salt, which a pound of the Potash contains.

These weights may be used also, where great exactness is required, for trying the strength of the strongest lyes as well as of weak ones. A weighed quantity of the strong lye being put into a convenient vessel, and the hydrometer immersed, pour in water till the instrument sinks to the proper mark with the 16 weight in the scale. The liquor is then to be weighed again, to find the quantity of water added. So many times as this water exceeds the weight of the lye, so many ounces of salt are contained in sixty-four ounces of the lye, or so many quarters of an ounce in the pound.

To make the lye for the assay of Potash, the half-ounce of powdered Potash is to be shaken with the sixty-three half-ounces of water, or rubbed in a mortar, that the salt may be fully extracted: or the Potash may be boiled with a little of the water; the clear part poured off into a tared glass, in which there should be some cold water to keep it from cracking; the undissolved part of the Potash boiled with a little more water, and put to the rest; and the whole quantity made up with cold water to thirty-two ounces: for the greater convenience, the liquor should always be weighed in the same vessel, and one weight kept for its tare.

As different waters differ somewhat in gravity, it will be proper to try the instruments occasionally in water alone, that allowance may be made, in case the water used in the assay should prove heavier or lighter than that which the instrument was adjusted with. It does not appear that common waters affect the gravity of the lye any otherwise than in proportion to their own gravity. An hydrometer was adjusted so as to sink to the mark in rain-water, which had been caught in a clean vessel in an open plain: salt of tartar being then dissolved in the water in the standard proportion, the weight which sunk the hydrometer in the solution was marked 16, and divided into assay-ounces as above described. In one of the heaviest pump-waters I could meet with, the same instrument required an additional weight of one assay-ounce to sink it; and in a standard lye made with this water, it required also exactly one ounce more than the sixteen.

The effect of heat in varying the gravity of the liquor, is not only more considerable, but less uniform. Some standard lyes being heated, and a thermometer and hydrometer immersed in them, and examined from time to time as the liquors cooled; it appeared, that while the thermometer sunk from 80 to about 60 of *Fahrenheit's* scale, the hydrometric weight varied near 3 assay-ounces; but in an equal interval below 60, it did not vary above half so much. There are two ways of avoiding any errors from this cause; one is, to make the assay-lye always with cold water from a well or spring; for it appears that spring-waters,
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as they issue from the earth, are, in different climates and different seasons, nearly always of the same temperature; viz. about 48 or 50 of *Fahrenheit's* thermometer; and happily about this degree of warmth, a variation of several divisions of the thermometer scarce sensibly affects the gravity of the lye. The other way is, to make the assay-lye by boiling the Potash with a part of the water, as above mentioned; hanging a thermometer in the liquor, and waiting till it has always fallen to the same degree of heat, before assaying it with the hydrostatic instruments, which in this case must have their weights adjusted to that standard degree.

The thermometer must be a mercurial one: there is no occasion for its reaching higher than about 100 degrees of *Fahrenheit's* scale; but the divisions should be large, that the standard degree may be the more easily and exactly distinguished. It is to be hung with its ball in the liquor; a cylindric glass, about $3\frac{1}{2}$ inches wide in the inside, and $7\frac{1}{2}$ deep, affords convenient room both for it and the hydrometric instrument at the same time.

This process discovers the quantity of saline matter in the Potash with sufficient nicety. To determine whether this salt be the pure alkali which it ought to be, recourse must be had to operations of a different kind, such as that described in the following article.

Affay of the quantity of pure alkaline salt contained in Potashes.

THE true strength of potashes, as it depends on their quantity of pure alkaline salt, must be estimated from characters which belong to alkaline salts only; among which, the neutralization of acids is one of the chief. Several persons have, on this principle, endeavoured to ascertain the comparative strength of different Potashes, but not their absolute strength; nor do they seem to have always attended to certain circumstances necessary for the accuracy of the experiment.

If the whole substance of the Potash is used for mixture with the acid, a considerable error may arise from the earthy part; for the earthy matter in genuine potashes, or lime, or vegetable ashes fraudulently mixed, will saturate a portion of acid, as well as the true alkaline salt. The salt must therefore be separated from the earth, by solution in water and filtration.

The quantity of acid, necessary for the saturation of the lye, should be determined, not by drops or tea-spoonfuls, but by weight; and the point of saturation, not by the ceasing of the effervescence, which it is extremely difficult, if not impracticable, to hit with tolerable exactness, but by some effect less ambiguous and more strongly marked, such as the change of colour produced in certain vegetable juices, or on paper stained with them.

The finer sort of purplish blue paper used for wrapping sugar in, answers sufficiently well for this

this purpose; its colour being changed red by flight acids, and afterwards blue or purple again by flight alcalies. What I have chiefly made use of, and found very convenient, is a thick writing paper stained blue on one side with an infusion of lacmus or blue archil, and red on the other by a mixture of the same infusion with so much dilute spirit of salt as is sufficient just to redden it. The paper is washed over with a brush dipt in the respective liquors, two or three times, being dried each time, till it has received a pretty full colour, and afterwards cut in slips a quarter of an inch or less in breadth; a bit of the end of one of the slips being dipt in the liquor to be tried, the red side turns blue while any of the alcali remains unsaturated, and the blue side turns red when the acid begins to prevail. If either the acid or alcali considerably prevails, the paper changes its colour immediately on touching the liquor: if they prevail but in a low degree, the change is less sudden. The part dipt is always to be cut off before a fresh trial.

The acid I have employed is spirit of salt; which was preferred to the other mineral acids, on account of its having no action upon the marine salt contained in the Potashes. The most convenient method I could contrive of managing the process for an assay of Potash, is the following.

Two drams avoirdupois, or $\frac{1}{8}$ of an ounce, of pure salt of tartar, perfectly dried by fusion in an iron ladle, as already mentioned, are to be dissolved in an ounce or two of water; it
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will be proper to have for this use a cylindrical glass vessel about 6 inches deep and 2½ wide.

Take a quantity of spirit of salt, and dilute it with 10 or 12 times its measure of water; fill with this mixture a vial that will hold somewhat more than 4 ounces of water: the vial which I find most commodious is nearly of the shape of an egg, with a broad foot that it may stand sure, a funnel-shaped mouth for the convenience of pouring the liquor into it, and a kind of lip or channel at one side of the mouth, that the liquor may be poured or dropt out without danger of any drops running down on the outside. Hook the vial, by means of a piece of brass wire tied round its neck, to one of the scales of a balance; and counterpoise it, while filled with the acid liquor, by a weight in the opposite scale.

Pour gradually some of the acid from the vial into the solution of salt of tartar, so long as it continues to raise a strong effervescence; then pour or drop in the acid very cautiously, and after every small addition, stir the mixture well with a glass cane, and examine it with the stained papers. So long as it turns the red side of the paper blue, more acid is wanted: if it turns the blue side red, the acid has been overdosed. That there may be means of remedying any accident of this kind, without being obliged to repeat the whole preceding part of the experiment, it will be proper to reserve a little of the alkaline solution in another vial: this is always to be added to-
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wards the end, and washed out of the vial with a little water.

When the liquor appears completely saturated, making no change in the colour of the paper, hook the vial on the scale again, to see how much it wants of its first weight: this deficiency will be the quantity of the acid liquor consumed in saturating the two drams of alkaline salt. So much as this quantity wants of four ounces, so much, in proportion, of common water must be added to all the rest of the acid mixture. If for instance the quantity consumed in the saturation is three ounces, then, for every 3 ounces, or 3 pounds, or 30 pounds, of the acid liquor, must be added one ounce, or one pound, or ten pounds of water; the acid will thus be so adjusted, that four ounces of it will saturate two drams of alcali: it will be expedient to make another trial, to see whether it is exactly of this strength.

The apparatus being thus prepared, the assay of Potash is made as follows.

LET two drams of the powdered Potash be boiled for a minute with about an ounce of water: after standing a moment to settle, pour off the clear part into a small filter of paper, fitted into a wire funnel supported by its rim in the cylindric glass. Boil the remainder of the Potash with as much more water; and when the first lye has passed through, pour this into the filter, washing out the whole with a little fresh water; when all the liquor has run through the filter, which it will do.

do in a short time, pour in a little water, to wash out what salt may remain both in the paper, and in the undissolved earthy matter of the Potash ; when this has dropt through, a little more water may be added, till the drops that fall from the filter make no change in the colour of the red paper. This part of the operation is less tedious in practice than it may seem to be in the description ; and the assayer may easily contrive, where dispatch is necessary, to have a number of these lyes preparing at the same time.

Charge the vial with the adjusted acid mixture, and counterpoise it with a weight in the opposite scale. Pour the acid into the lye as above mentioned, till the mixture makes no change in the coloured papers ; and weigh the vial again, to see how much of the acid has been consumed. Four times this quantity of pure alkaline salt is contained in every pound of the potash.

To avoid any little embarrassment or error, that may sometimes happen, even in this small degree of calculation ; the four ounce weight may be marked XVI, the two ounce VIII, the one ounce IV, the half-ounce II, the quarter of an ounce I ; the two drams 8, the one dram 4, the half-dram 2, and the quarter of a dram 1. By this means the weights in the scale will always express at once the ounces and drams of alcali contained in a pound of the potash.

A person accustomed a little to this operation, will be able to determine by it, not only

only the quantity of pure alcali, but whether the alcali has any injurious causticity. Plain alcalies effervesce with the acid, from almost the first drop, till the saturation is completed : those which are fully caustic, make no effervescence at all ; and those which are caustic in part, do not begin to effervesce, till a considerable quantity of the acid has been added, more or less according to the degree of causticity.

As acids, added to potash in substance, act upon its earthy part as well as its alkaline salt, I was led to make some trials of an acid already saturated with earth. Among the natural or artificial compounds of this kind, the bitter salt, prepared from the bittern of sea-water, promised best. It was hoped that the process would thus be considerably abridged, and no more be needful than to boil the two drams of Potash with two or three ounces of water, for a minute or two, and add some adjusted solution of the bitter salt, till the red papers dipt in the milky mixture just ceased to be turned blue. It appeared, that for many sorts of Potashes this simple process would answer sufficiently well ; but that cases may occur in which it would be extremely fallacious. If the Potash contains quick-lime, the bitter solution will act upon the lime, as well as on the alkaline salt. And indeed, if this did not happen, the quick-lime, remaining after the saturation of the alcali, would give an impregnation to the liquor not easily distinguishable from that of the alcali itself. I therefore forbear giving any detail of

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the experiments made on the above principle;
and apprehend that the methods of trial al-
ready recommended, by the hydrostatic in-
struments and acid spirits, will satisfactorily
determine the quality of any kind of Pot-
ashes.

F I N I S.



